CALIFORNIA ENERGY COMMISSION
Inter-state Generation and Delivery of Renewable Resources into California from WECC states

Inter-state Transmission Evaluation

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DPC Team

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Agenda

- Near Term Intertie Usage (out to 2010)
  - PDCI and COI transmission availability
  - Issues and Problems
- Long Term Intertie Requirements (beyond 2010)
  - New Intertie options
  - Import capability and limitations
  - Issues and problems

Historical PDCI and COI Operations

- How has transmission owners used PDCI and COI in the past?
- What is the potential availability for base load and intermittent renewable resources?
- What work must be completed to determine availability?

PDCI Historical loading 1996-1999

Month	Design Rating	Actual Max Avail.	Actual Max Sched.	Max % Usage	Average Hourly PDCI Rating (Heavy Load)	Average Hourly N-S Loading (Heavy Load)	Average N-S % Usage	Average Hourly S-N Loading
Jul-96	2990	2990	2990	100%	2990	2536	85%	2031
Jul-97	2990	2759	2756	100%	2693	2479	92%	2141
Jul-98	2990	2735	2637	96%	2499	2026	81%	656
Jul-99	2990	2784	2651	95%	2517	2093	83%	1399
Aug-96	2990	2990	2965	99%	2990	2146	72%	1260
Aug-97	2990	2759	2737	99%	2607	2257	87%	1625
Aug-98	2990	2735	2694	99%	2631	1780	68%	641
Aug-99	2990	2784	2651	95%	2595	2093	81%	1399
Avg	2990	2817	2760	98%	2690	2176	81%	1394

PDCI Historical Loading 2000-2004

Month	Design Rating	Actual Max Avail.	Actual Max Sched.	Max % Usage	Avg Hourly PDCI Rating (Heavy Load)	Avg Hourly N-S Loading (Heavy Load)	Average N-S % Usage	Avg Hourly S-N Loading
Jul-00	2990	2871	2555	89%	2568	1330	52%	61
Jul-01	2990	2875	2467	86%	2613	136	5%	423
Jul-02	2990	2990	2850	95%	2478	1998	81%	1553
Jul-03	2990	2990	2461	82%	2439	1504	62%	185
Jul-04	2990	1956	1840	94%	1405	558	40%	89
Aug-00	2990	2871	2583	90%	2541	981	39%	715
Aug-01	2990	2875	2363	82%	2633	593	23%	178
Aug-02	2990	2990	2658	89%	2712	1946	72%	633
Aug-03	2990	2990	2913	97%	2611	1598	61%	253
Aug-04	2990	1956	1921	98%	1523	373	24%	221
Avg	2990	2736	2461	90%	2352	1102	50%	431

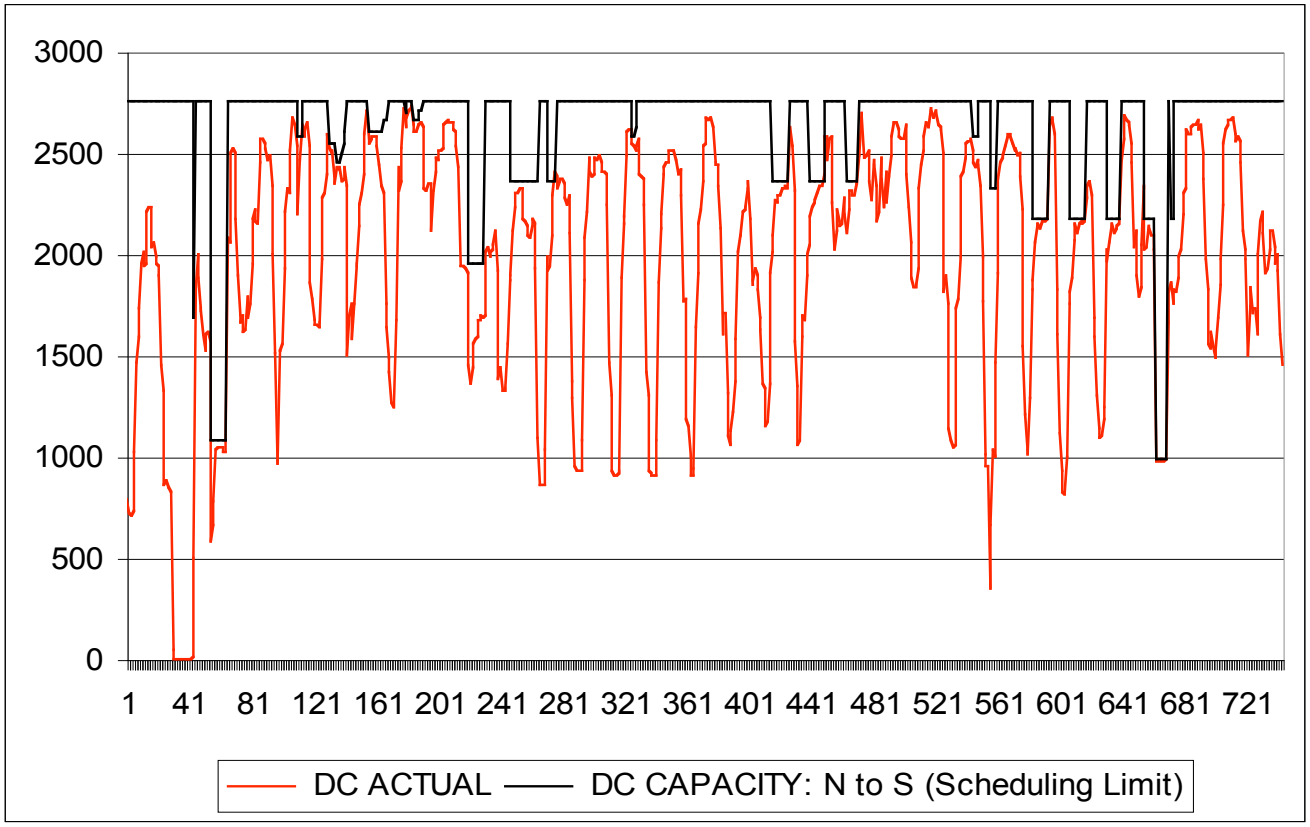
PDCI Historical Operation

- Power flow characteristics have changed between the two periods.
  - Maximum rating continues close to design
  - Maximum peak usage continues to be high
    - 98% of available for 1990's
    - 90% of available for 2000's
  - Average hourly heavy load rating remains high
    - 90% for 1990's
    - 79% for 2000's

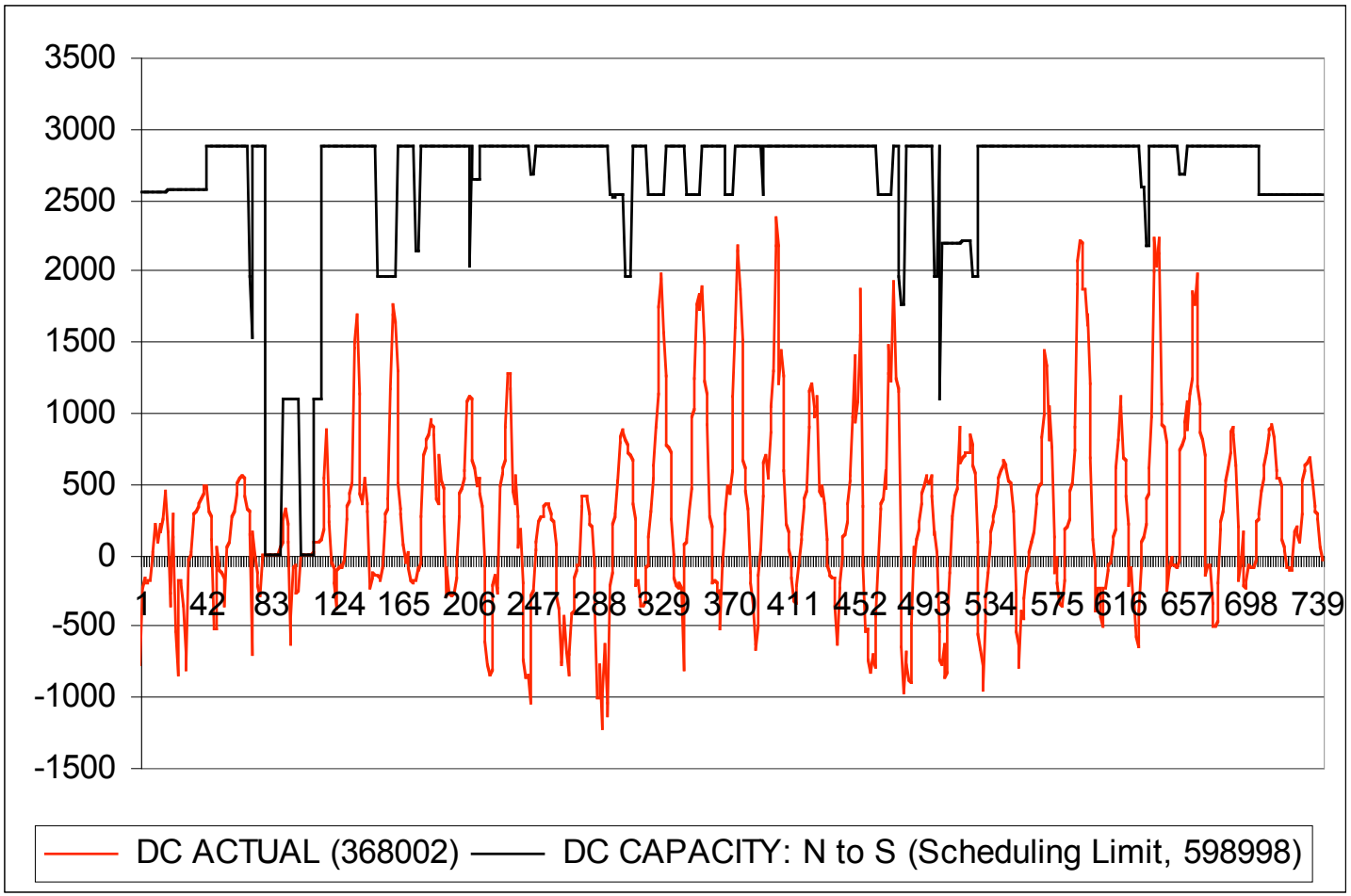
PDCI Operation Cont'd

- Average N-S Usage has changed
  - 81% for 1990's
  - 50% for 2000's
- Potential reasons
  - California low load growth
  - PNW experiencing dry hydro conditions
  - PNW customers using more hydro
  - Little excess energy for California

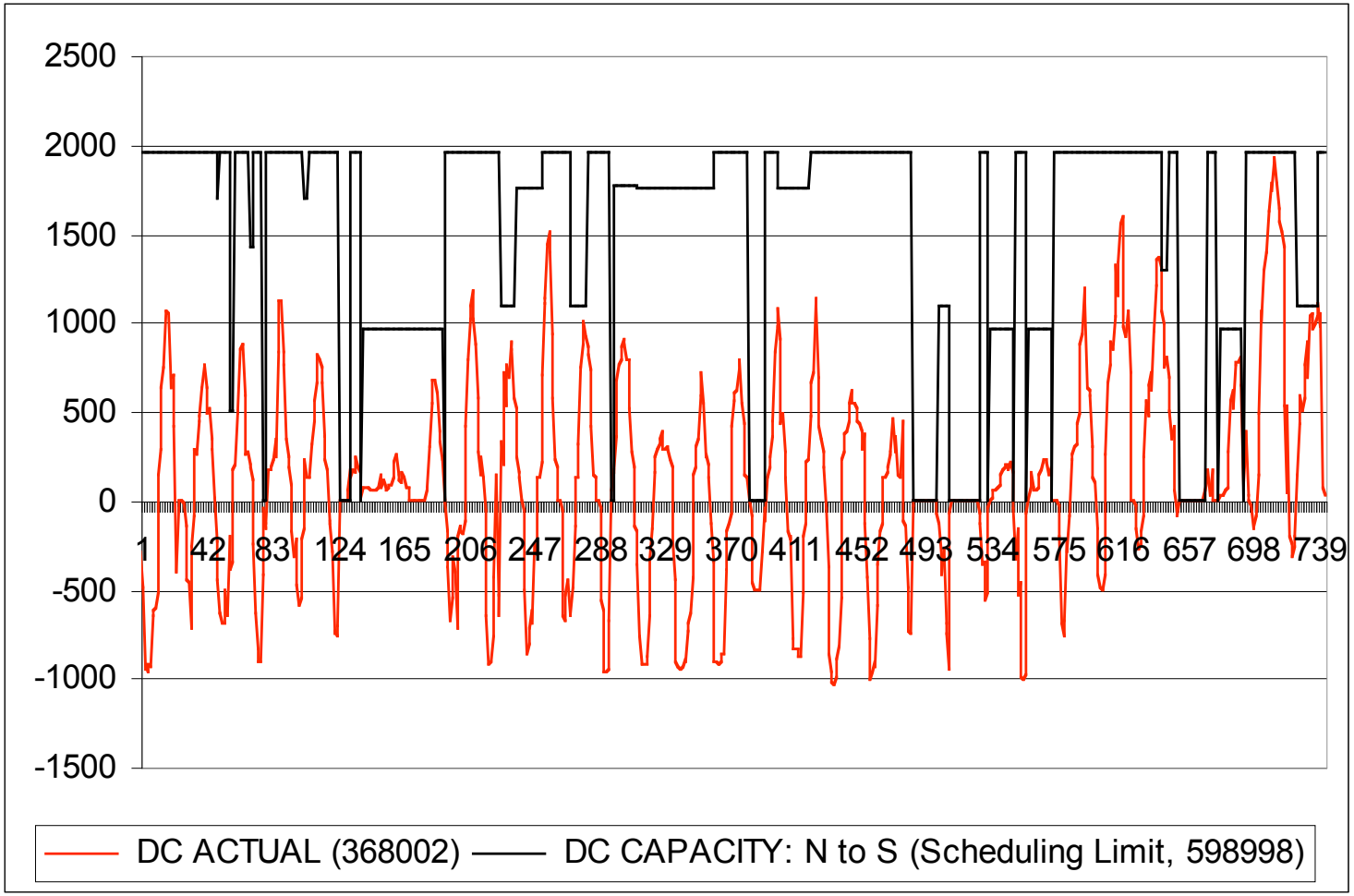
PDCI August 1997



PDCI August 2001



PDCI August 2004



COI Historical Operation 1990's

Month	Design Rating	Actual Max Rating	Actual Max Sched	Max % Useage	Avg Hourly COI Rating (Heavy Load)	Avg Hourly N-S Loading (Heavy Load)	Avg N-S % Usage
Jul-96	4800	4800	4775	99%	4800	3624	76%
Jul-97	4800	3450	3460	100%	3398	3193	94%
Jul-98	4800	4375	3881	89%	3931	2312	59%
Jul-99	4800	4548	4089	90%	4243	3195	75%
Aug-96	4800	4800	2948	61%	4800	3186	66%
Aug-97	4800	4050	3925	97%	3427	3165	92%
Aug-98	4800	4375	4011	92%	4219	1610	38%
Aug-99	4800	4355	3986	92%	3916	2900	71%
Avg	4800	4344	3884	89%	4092	2898	71%

COI Historical Loading 2000's

Month	Design Rating	Actual Max Rating	Actual Max Sched	Max % Useage	Avg Hourly COI Rating (Heavy Load)	Avg Hourly N-S Loading (Heavy Load)	Avg N-S % Usage
Jul-00	4800	4200	3352	80%	4142	1644	40%
Jul-01	4800	4300	3613	84%	4027	512	13%
Jul-02	4800	4300	3564	83%	3643	2577	71%
Jul-03	4800	4800	3519	73%	3931	2304	59%
Jul-04	4800	4600	3923	85%	4089	2200	54%
Aug-00	4800	4200	3518	84%	4094	1105	27%
Aug-01	4800	4300	3753	87%	4166	1286	31%
Aug-02	4800	4300	3760	87%	3825	2769	72%
Aug-03	4800	4750	3851	81%	3926	2470	63%
Aug-04	4800	4650	4372	94%	4185	2487	59%
Avg	4800	4567	3994	87%	3979	2575	49%

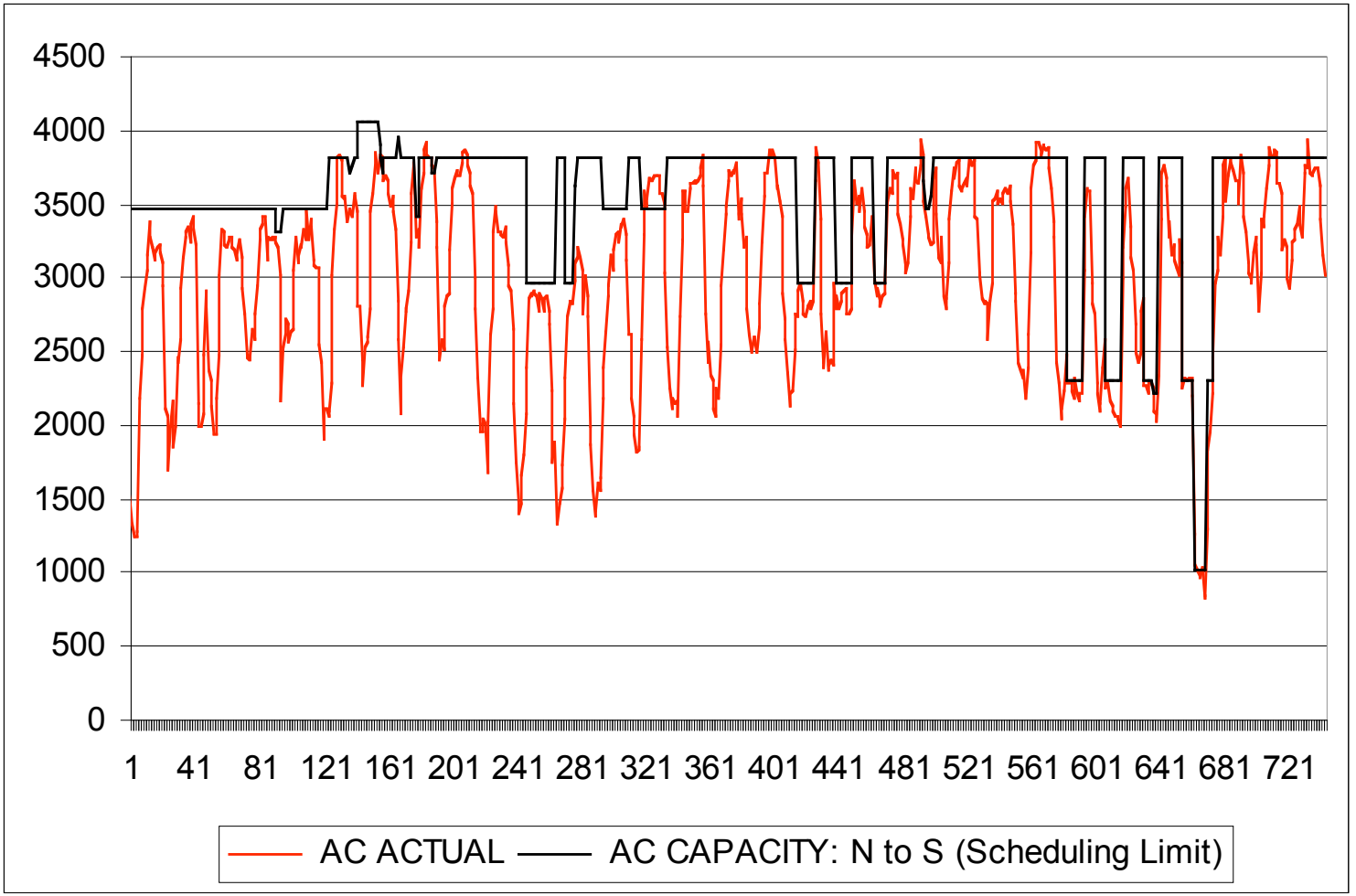
COI Operations

- Power flow characteristics have changed between the two periods.
  - Maximum rating continues close to design
  - Maximum peak usage continues to be high
    - 89% of available for 1990's
    - 87% of available for 2000's
  - Average hourly heavy load rating constant
    - 85% for 1990's
    - 83% for 2000's

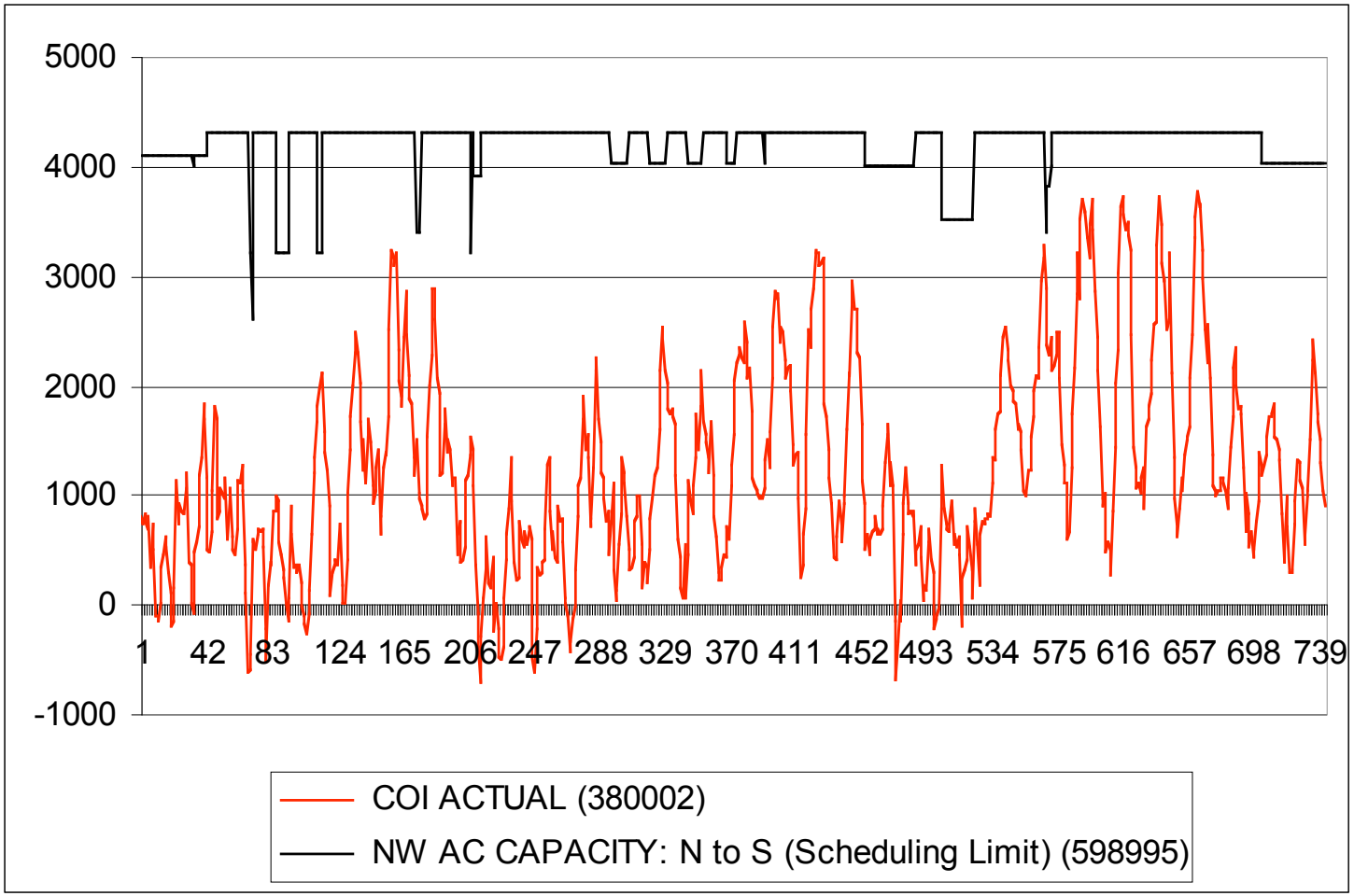
COI Operation Cont'd

- Average N-S Usage has changed
  - 71% for 1990's
  - 49% for 2000's
- Potential reasons
  - California low load growth
  - PNW experiencing dry hydro conditions
  - PNW customers using more hydro
  - Little excess energy for California

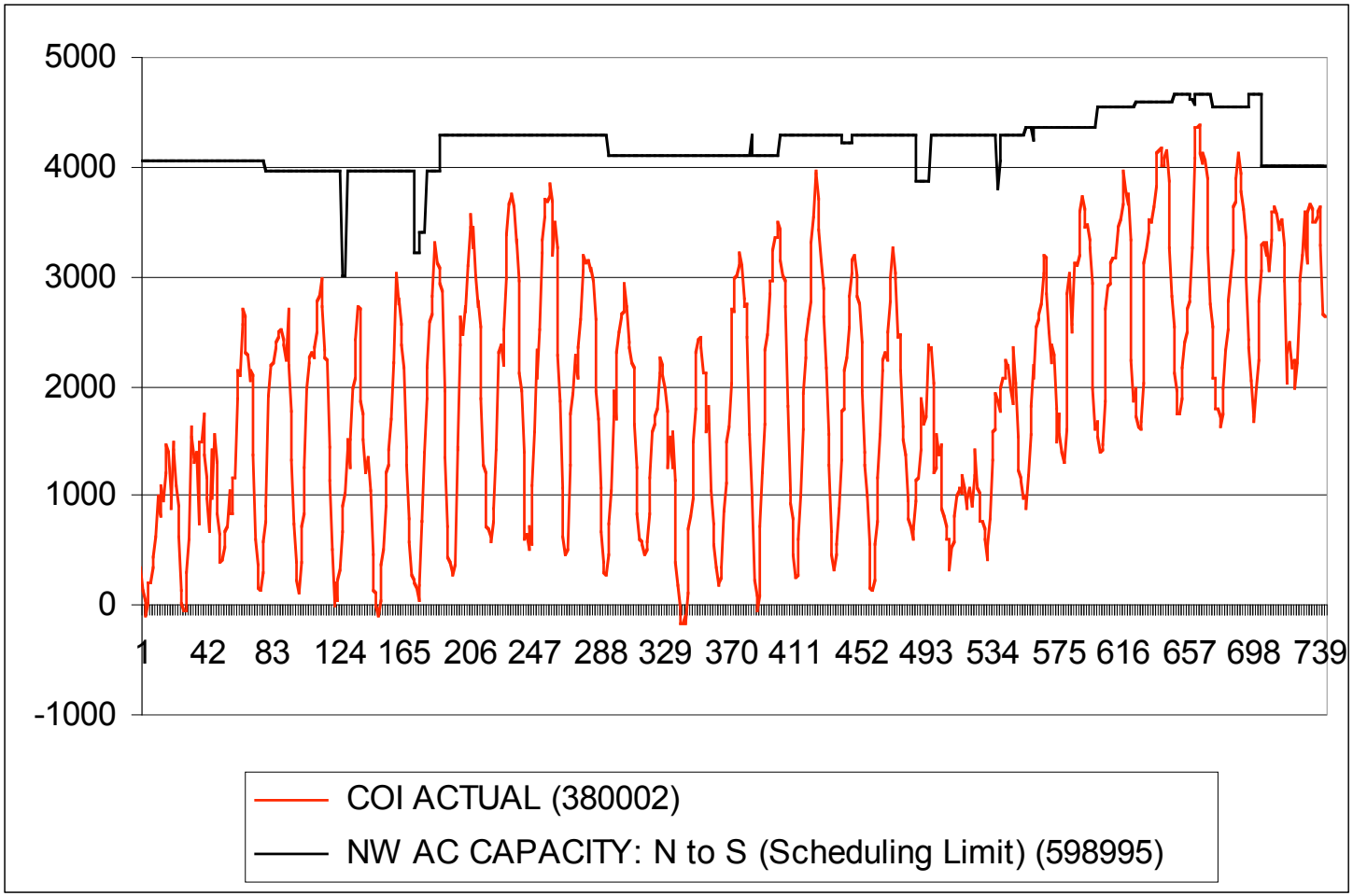
COI August 1997



COI August 2001



COI August 2004



Potential PDCI/COI Renewable Usage

- Utilities continue to purchase on-peak, shaped power from Northwest
  - COI curtailments will impact availability
  - Wind and other intermittent renewables could deliver power during non-peak hours
  - Wind/hydro integration contracts could be valuable
  - Base load (geothermal) may be susceptible to on-peak curtailments
  - Base Load competes with on-peak hydro
  - Would a geothermal/hydro on-peak shaped product work?

Common Characteristics PDCI and COI

- Nomograms impact hourly ratings
- Actual line flows impact COI and PDCI
- Loop flows impact availability
- Hydro conditions impact availability
- Pacific Northwest curtailments impact availability

Long Term Transmission Requirements

Study Conditions

- Assume utility developed data sets for power flow analyses
  - Maximum imports across COI and PDCI
  - A maximum stress case
- If we assume that for the summer 2010 peak, renewables are fully added to maximum rating of interties; then our ATC analyses are valid results for transmission expansion requirements

Study Methodology

- Model three out-of-state renewable resource groups
- Model proposed high-voltage transmission upgrades
- Calculate peak hour available transfer capability from out-of-state renewable resource groups to California
- Determine how much power can be imported before transmission limits are reached

Out-of-State Resource Groups

- Fredonyer Hills - Northwest Source
  - Columbia Valley Wind – 3000 MW
  - Southern Oregon Wind – 2000 MW
  - Idaho/Nevada Wind – 1000 MW
- Reno Source
  - Reno Wind – 1000 MW
  - Reno Geothermal – 600 MW
  - Dixie Geothermal – 500 MW
- Southern Source
  - Las Vegas Solar – 1000 MW
  - Arizona Solar – 1000 MW

Proposed Transmission Upgrades

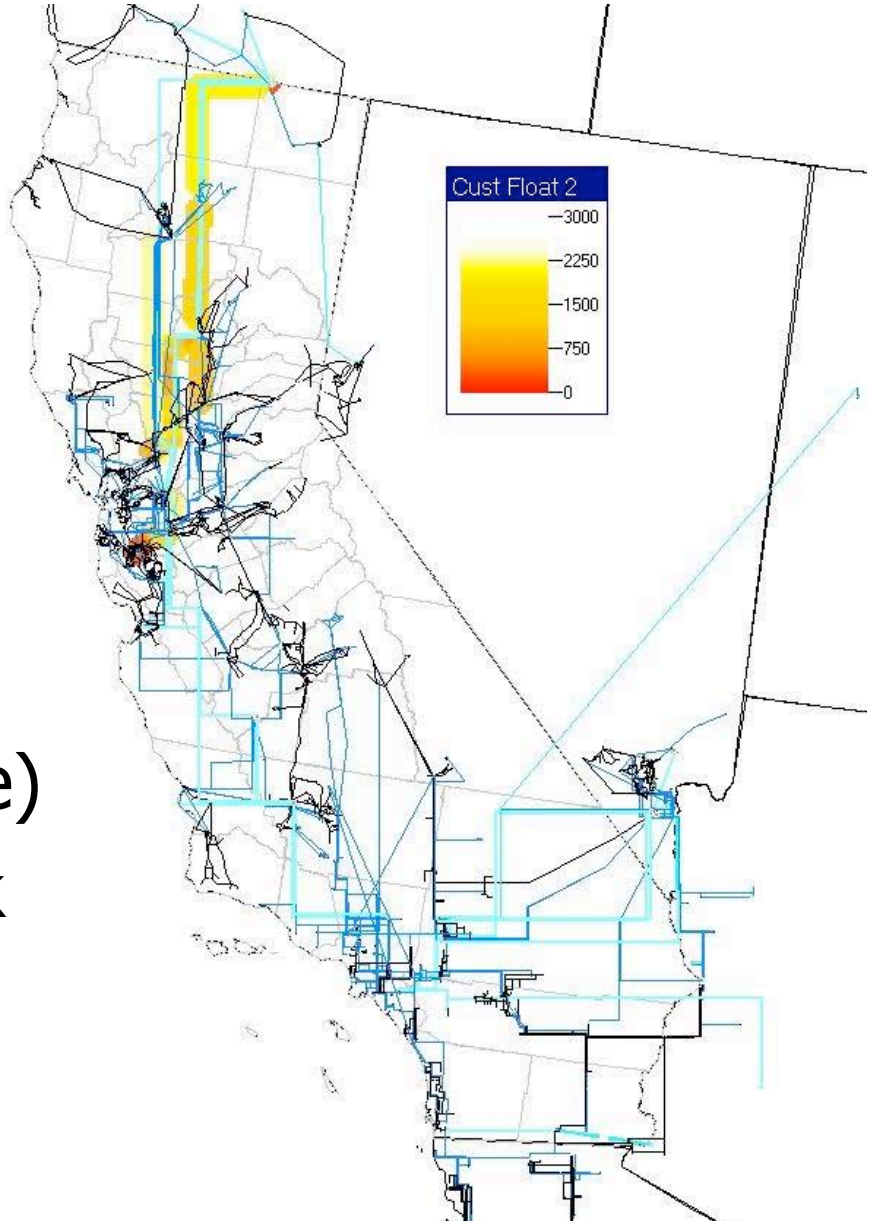
- Option 1:
  - California-Oregon intertie (COI), Pacific AC intertie (PACI), Alturas transmission line
- Option 2:
  - Trans-Sierra high-voltage line through Susanville
- Option 3:
  - Pacific DC intertie (PDCI) tap in Northwest Nevada
- Option 4:
  - Palo Verde-Devers II

Available Transfer Capability (ATC) Methodology

- Peak-load power flow case
- Ramp up out-of-state renewable generators
- Ramp down in-state generators, except
  - Nuclear and base load
  - Reliability-Must-Run (RMR)
  - Renewables
- Consider all single transmission line outages (n-1) at 100 kV and above in California
- Determine which transmission elements will become overloaded by importing renewables
  - How much can we import?
  - Which transmission lines cause limitations?
  - Which outages cause limitations?

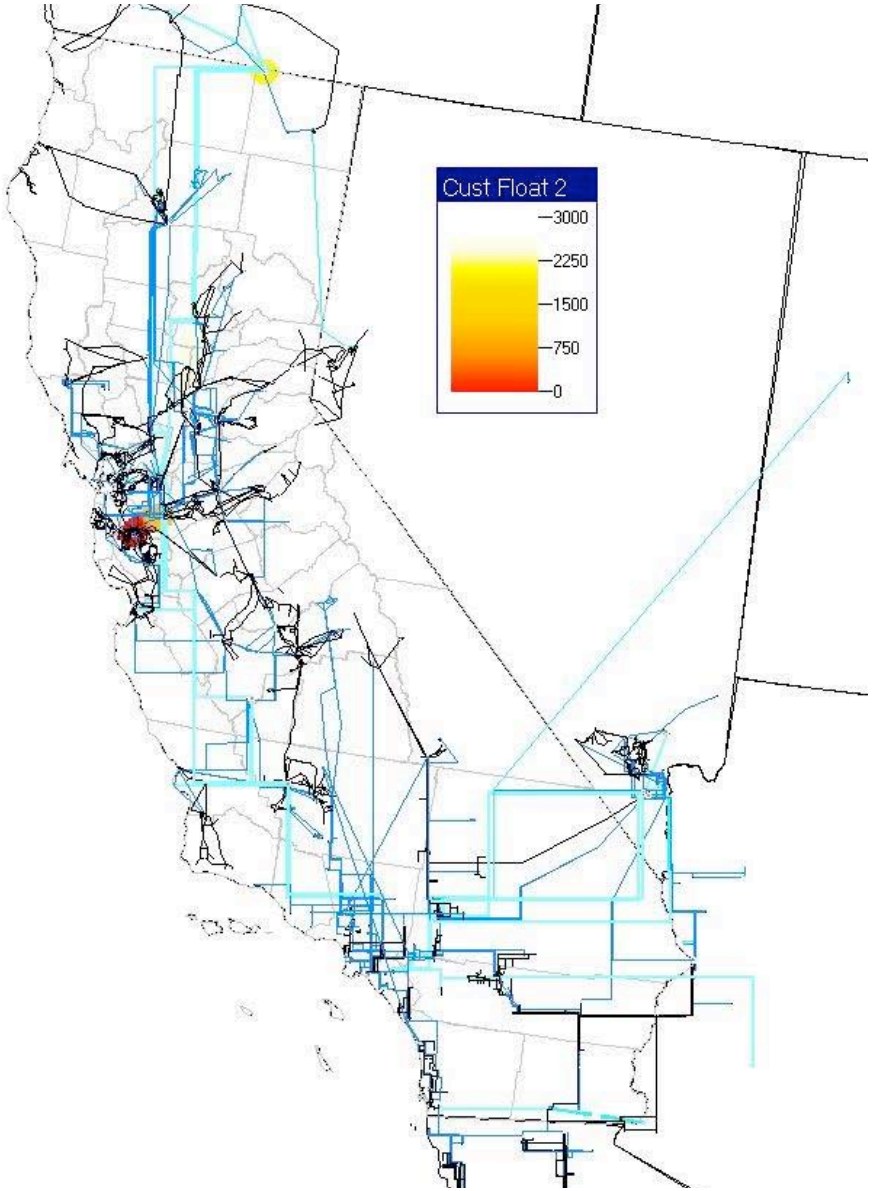
Import Limiters

- Maximum MW import allowed by high-voltage transmission lines (115 kV and above)
- Shown: 2010 peak load, Northwest Source, no transmission upgrades



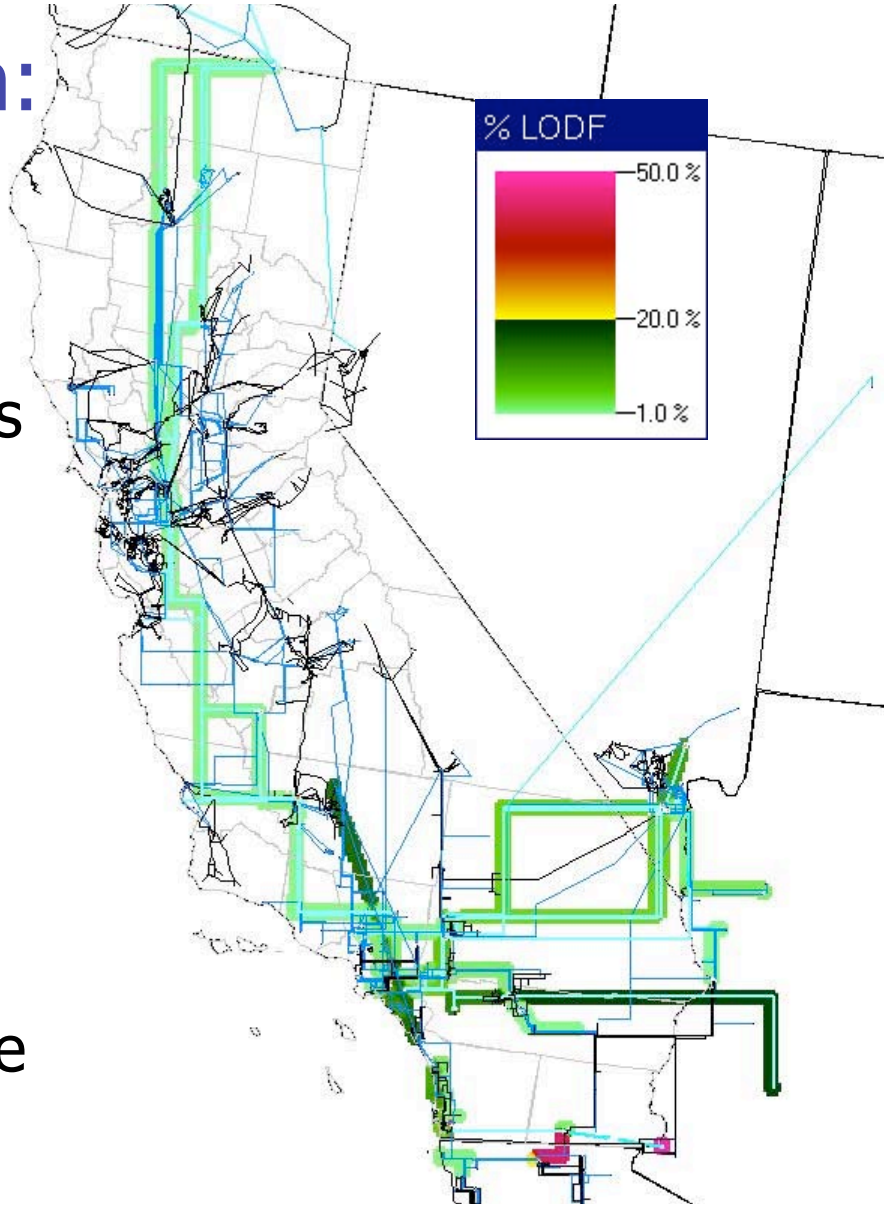
Import Limiter
COI/PACI/Alturas Upgrade

- Upgrade relieves problems associated with COI, but increas limitation between Tracy substation and Bay Area load center
- Shown: 2010 peak load, Northwest Source, COI/PACI/Alturas transmission upgrade



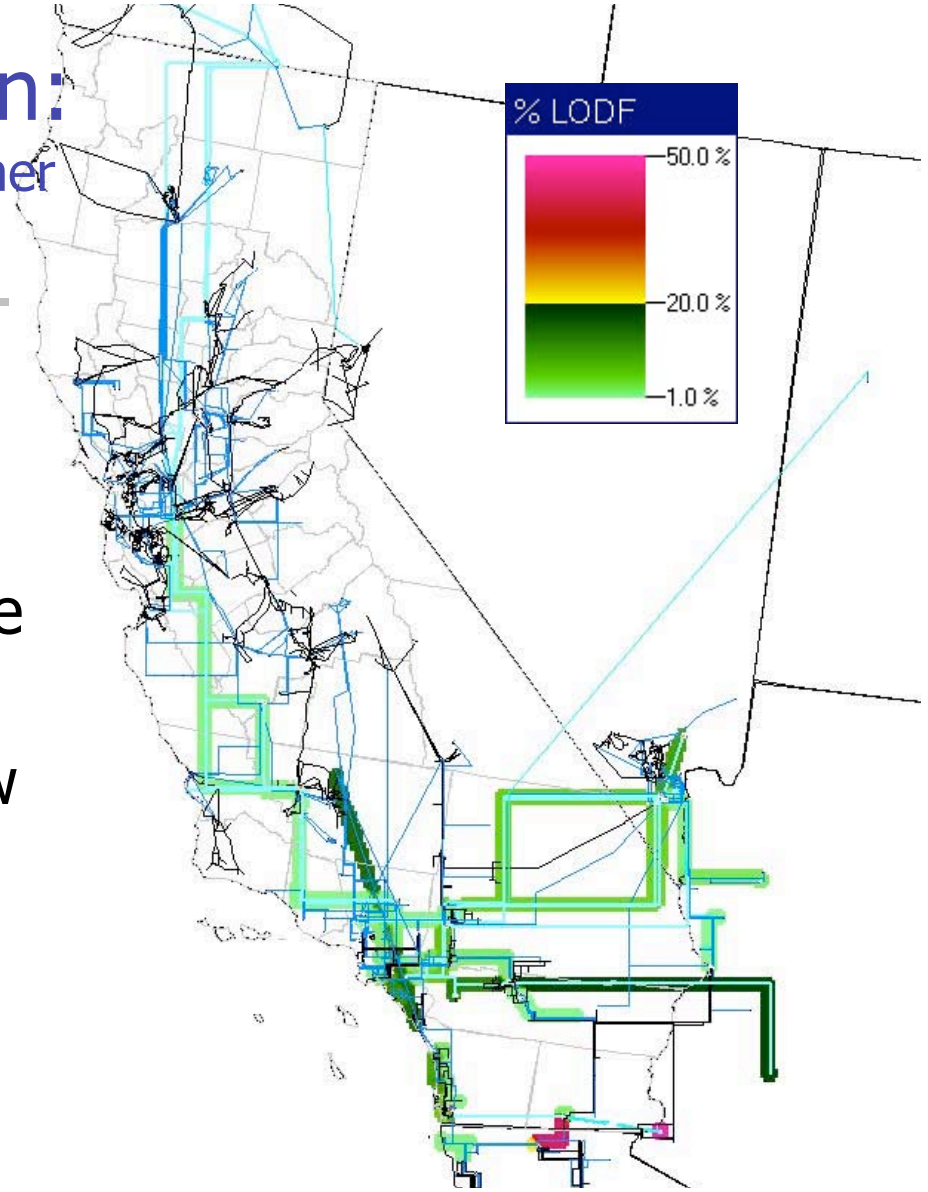
Outage Distribution:
Miguel 500/230 kV Transformer

- Most flow re-distributes in the south, but 3.6% loops around the Western Interconnect and onto COI, prior to any additional imports
- Imports in one area can be limited by outages throughout the network
- Shown: 2010 peak load, Northwest Source, no



Outage Distribution:

Miguel 500/230 kV Transformer
COI/PACI/Alturas Upgrade



- 3.7% loops onto the COI (new circuit included in the intertie definition)
- Increased outage flow on the COI with upgrade, but decreased share on each line
- Shown: 2010 peak load, Northwest Source

Limitations to New COI Line

COI Import	Limiter	Contingencies
0	ADCC to Newark E 230 kV	Base Case
1352	Tesla F to ADCC 230 kV	5 contingencies
1458	ADCC to Newark E 230 kV	4 contingencies
1554	Tesla F to ADCC 230 kV	13 contingencies
1685	Miraloma to Mirlom CKt 3 & 4, 13.8-500 kV; 13.8/230 kV	Base Case
1707	ADCC to Newark E	10 contingencies

Limitations to New Trans Sierra Line

Line Import	Limiter	Contingencies
81	ADCC to Newark E 230 kV	Base Case
220	Malin to Malrou21 500 kV	Base Case
440	COI	29 contingencies
1596	Tesla F to ADCC 230 kV	5 contingencies
1690	ADCC to Newark 230 kV	4 contingencies
1705	Miraloma to Mirlom CKt 3 & 4, 13.8-500 kV; 13.8/230 kV	Base Case

Limitations to Importing over PDCI

PDCI Import	Limiter	Contingencies
362	COI	16 contingencies
381	Malin to Malrou21	Base Case
402	COI	12 contingencies
505	ADCC to Newark E 230 kV	Base Case
1200	TABVAC11 to TABVAC12 500 kV	Base Case
1451	TABVAC12 to VACA-DIX 500 kV	Base Case

Limitations to PV-Devers 2

PV-Devers2 Import	Limiter	Contingencies
351	COI	15 Contingencies
367	Malin to MALROU21 500 kV	Base Case
386	COI	12 Contingencies
467	ADCC to Newark E 230 kV	Base Case
1311	TABVAC11-TABVAC12 TABVAC12 VACDIX 500 kV	Base Case
2408	TeslaF-ADCC; ADCC-Newark 230 kV	27 Contingencies

Study Limitations

- Peak-load capacity analysis cannot fully determine energy delivery capability
  - Transmission line loads during peak conditions are not necessarily present off-peak
  - It may be possible to import more power during off peak periods
- Unit commitment affects import capability
  - In-state unit availability and dispatch
  - Existing imports from other control areas
  - Baseline patterns were given in utility-supplied power flow cases

Results and Conclusions

- COI is vulnerable to in-state transmission outages and often limits import capacity
- Transmission upgrades must include in-state elements between interstate lines and load centers
- Additional interstate transmission lines are needed, especially from the PNW
- Load growth through 2017 places additional strains on the in-state network

Further Study

- Conduct seasonal transmission power flow studies; not just ATC analysis
- Integrate power simulation analysis into the evaluation of interconnection studies
- Model potential inter-state power flows with and without renewable resource imports
- Evaluate and monitor potential transmission interconnections from other regions

Option 1: COI/PACI/Alturas

- New 500kV line from Captain Jack through Olinda to Tracy (CA), parallel to existing 500kV lines
- Extend 345kV Alturas line to Captain Jack
- New 230kV transmission line from Fredonyer Hills wind farm into Honey Lake
- Convert 60kV circuit to 230kV circuit from Honey Lake to Caribou

Option 2: Trans-Sierra Through Susanville

- New Valley Road 500kV bus
- New 345/500 kV transformer at Valley Road
- New Valley Road to Table Mountain 500kV Line
- New 500kV line from Table Mountain to Tracy/Tesla

Option 3: PDCI Tap in Northwest Nevada

- New taps into PDCI in NV from Valley Road and Tracy, Nevada
- Determine effect of incremental PDCI schedule on California AC system
- No actual changes to PDCI
- Simulating in-area impacts if more power was delivered to PDCI terminus in CA

Option 4: Palo Verde-Devers II

- Add new 500kV circuit from Palo Verde to Devers
- Reconductor 230kV lines from Devers to Vista
- Reconductor 230kV lines from Devers to San Bernardino
- New 500kV circuit from Devers to Miguel